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(56) Documents cited
EP 0231607 A1 EP 0225971 A2 EP 0047813 A1
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(58) Field of search
UK CL (Edition J) G1U UC25
INT CL⁴ G01R

(54) **Diagnostic system for a motor vehicle**

(57) Each electronic control system 1, 2, 3, 4 in a motor vehicle 100 has a signal receiver for receiving a data demand signal from a diagnostic device, 25, an interpreter for interpreting the received data demand signal and a signal transmitter for transmitting an output signal to the diagnostic device 25. A signal receiving line connects all the signal receivers with each other in parallel, and a signal transmitting line connects all the signal transmitters with each other in parallel. The signal receiving line and signal transmitting line are connected with the diagnostic device 25 by a connector 24.

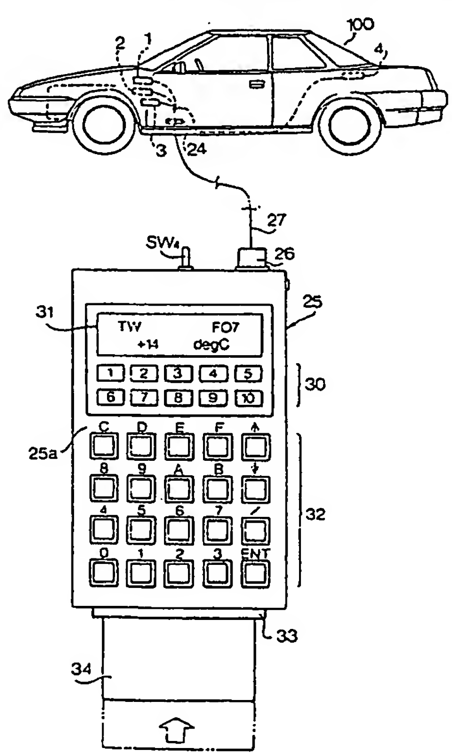

FIG. 1

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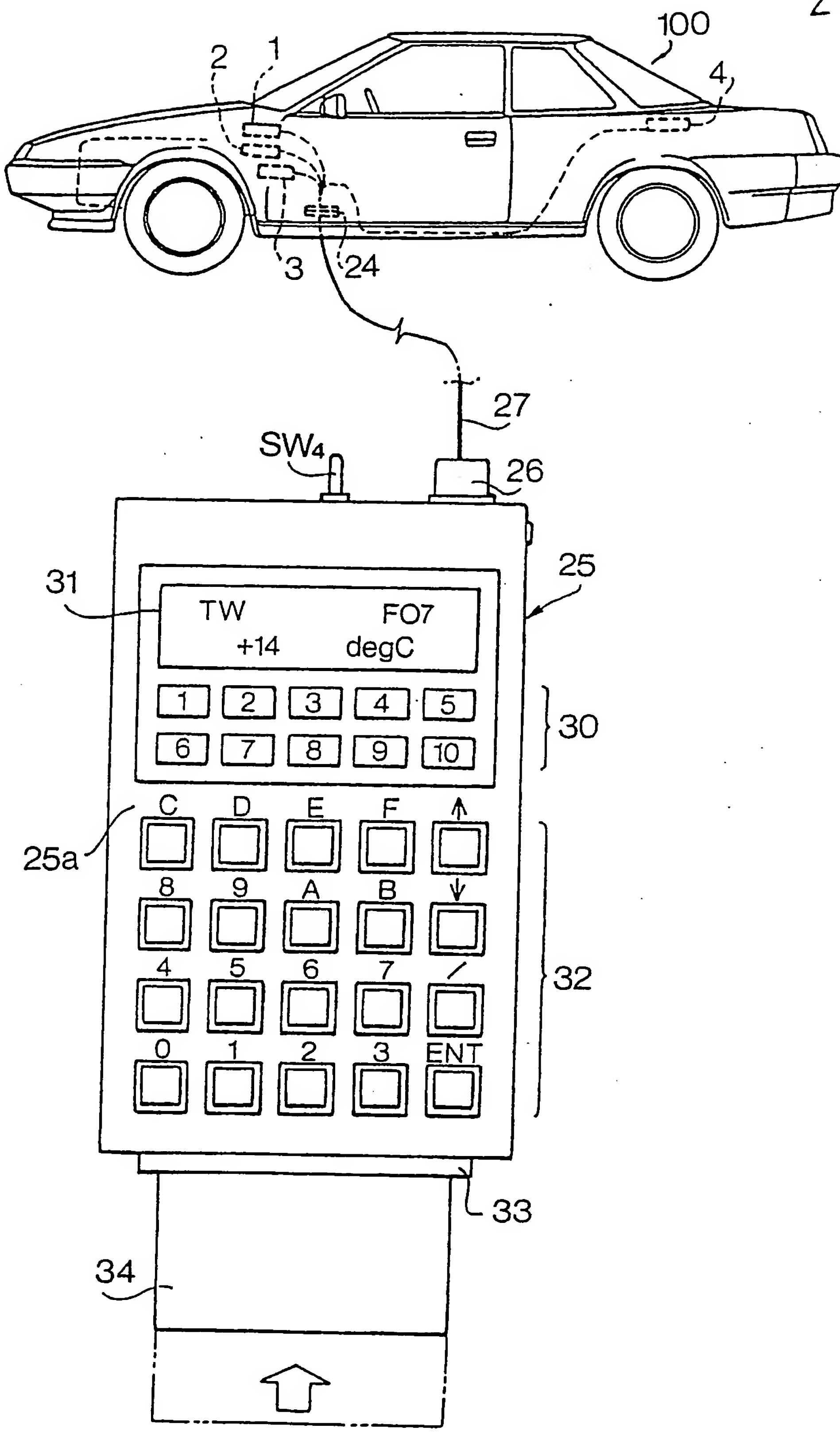

FIG. 1

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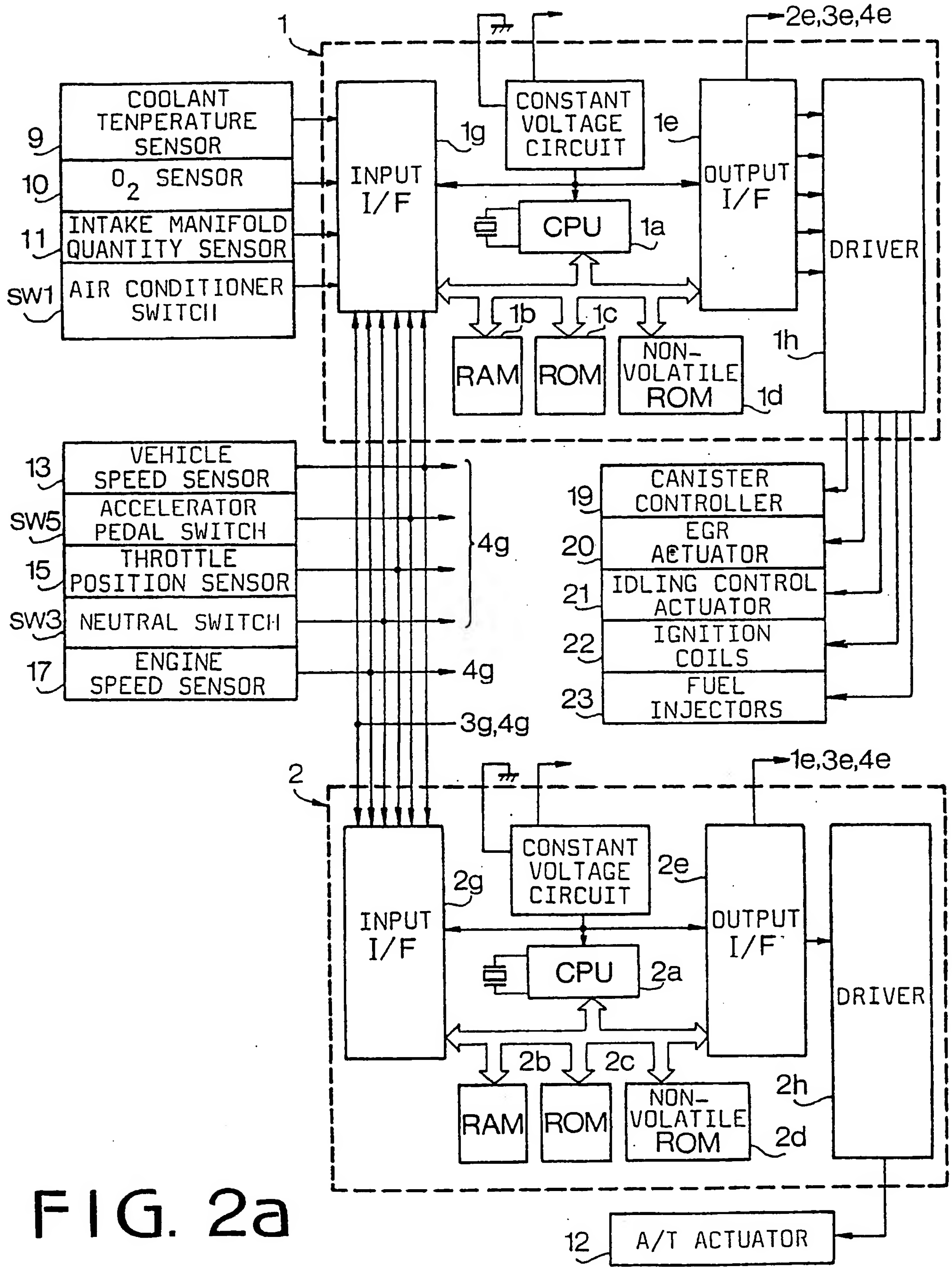

FIG. 2a

2217029

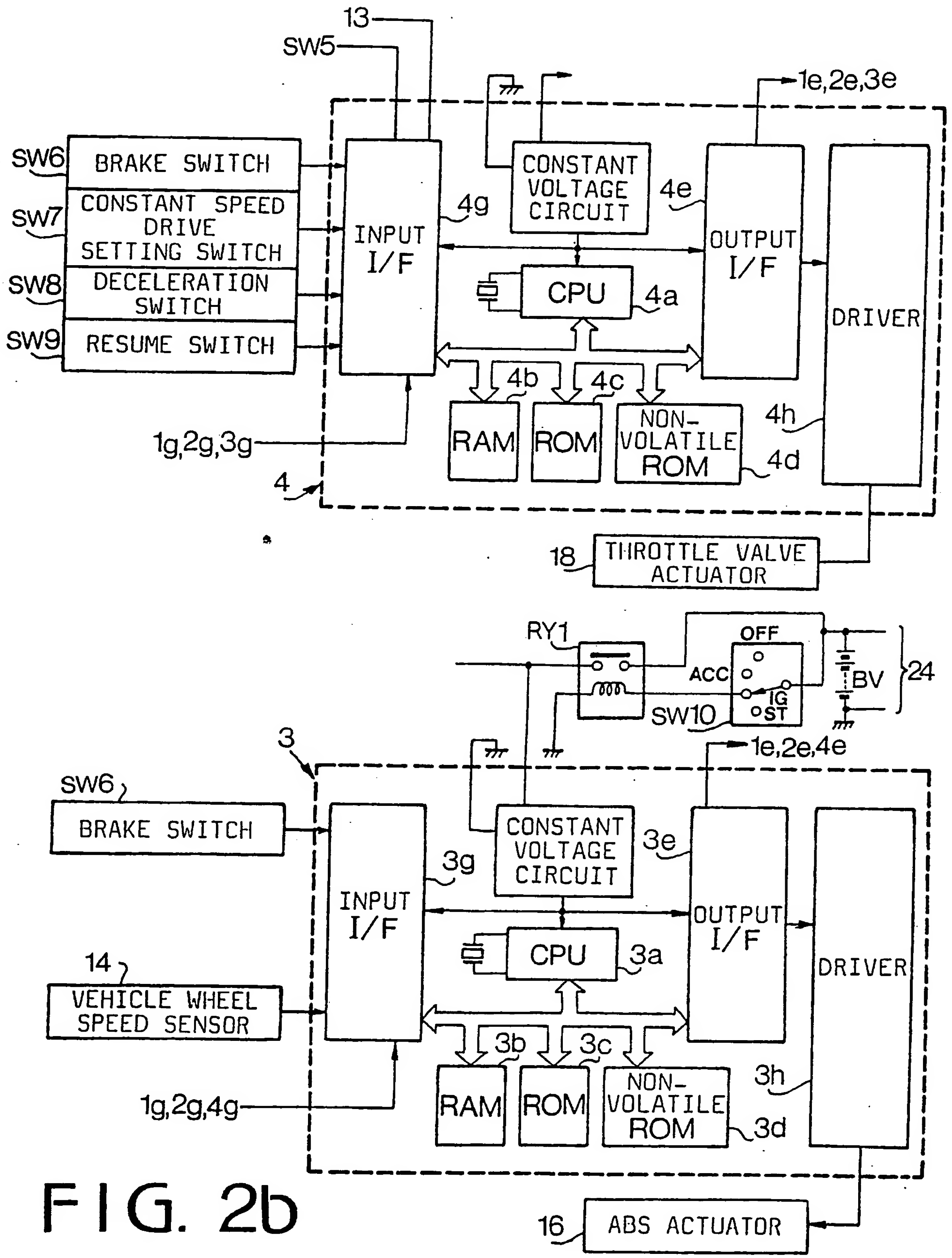

FIG. 2b

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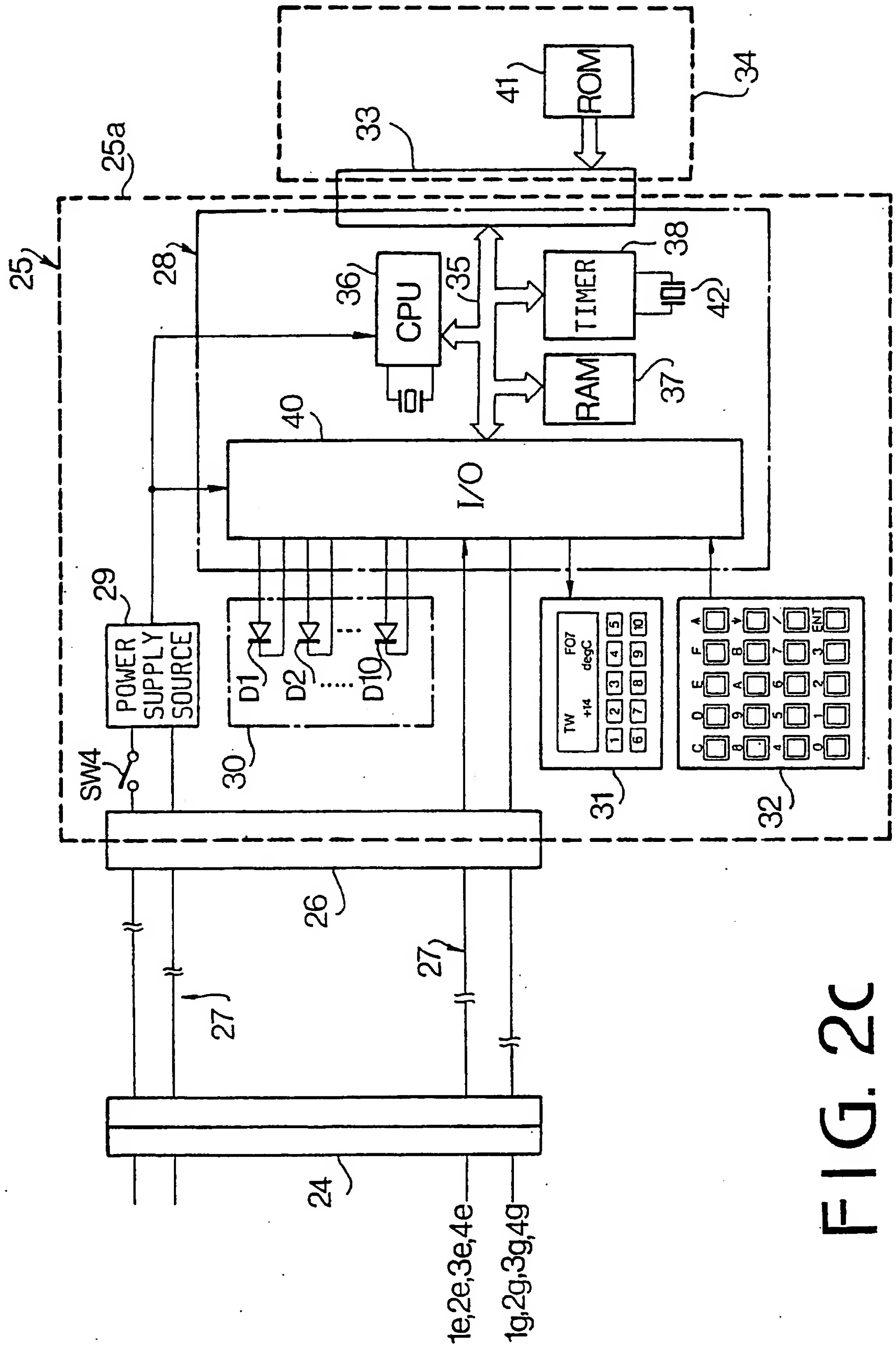

FIG. 2c

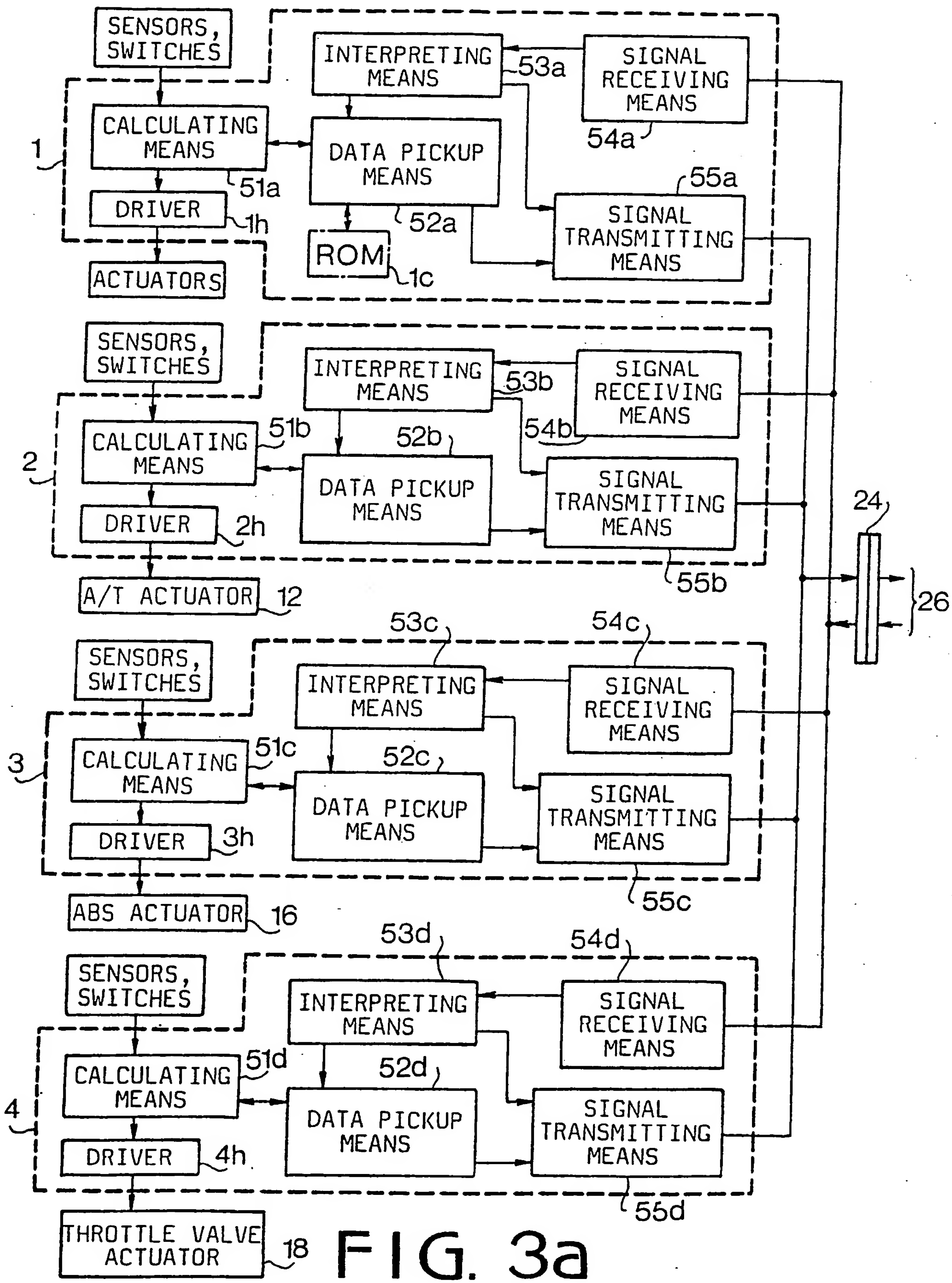
SENSORS, SWITCHES
INTERPRETING MEANS
SIGNAL RECEIVING MEANS
53a
54a
CALCULATING MEANS
DATA PICKUP MEANS
1
51a
55a
DRIVER
1h
52a
SIGNAL TRANSMITTING MEANS
ROM
ACTUATORS
1c
SENSORS, SWITCHES
INTERPRETING MEANS
53b
SIGNAL RECEIVING MEANS
CALCULATING MEANS
51b
52b
54b
2
DATA PICKUP MEANS
SIGNAL TRANSMITTING MEANS
DRIVER
2h
24
55b
A/T ACTUATOR
12
26
53c
54c
SENSORS, SWITCHES
INTERPRETING MEANS
SIGNAL RECEIVING MEANS
3
CALCULATING MEANS
51c
52c
DATA PICKUP MEANS
SIGNAL TRANSMITTING MEANS
DRIVER
3h
55c
ABS ACTUATOR
16
53d
54d
SENSORS, SWITCHES
INTERPRETING MEANS
SIGNAL RECEIVING MEANS
51d
52d
4
CALCULATING MEANS
DATA PICKUP MEANS
SIGNAL TRANSMITTING MEANS
DRIVER
4h
55d
THROTTLE VALVE ACTUATOR
18

FIG. 3a

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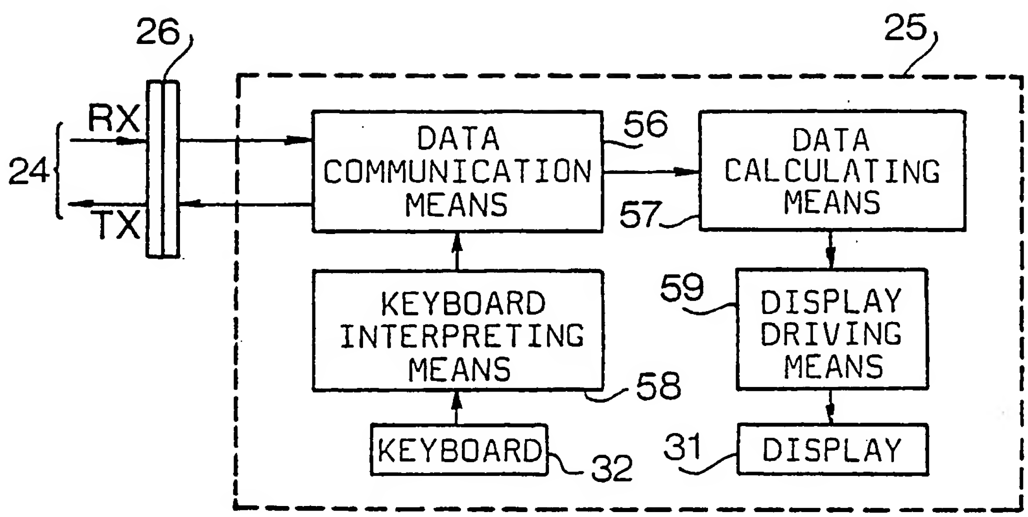

FIG. 3b

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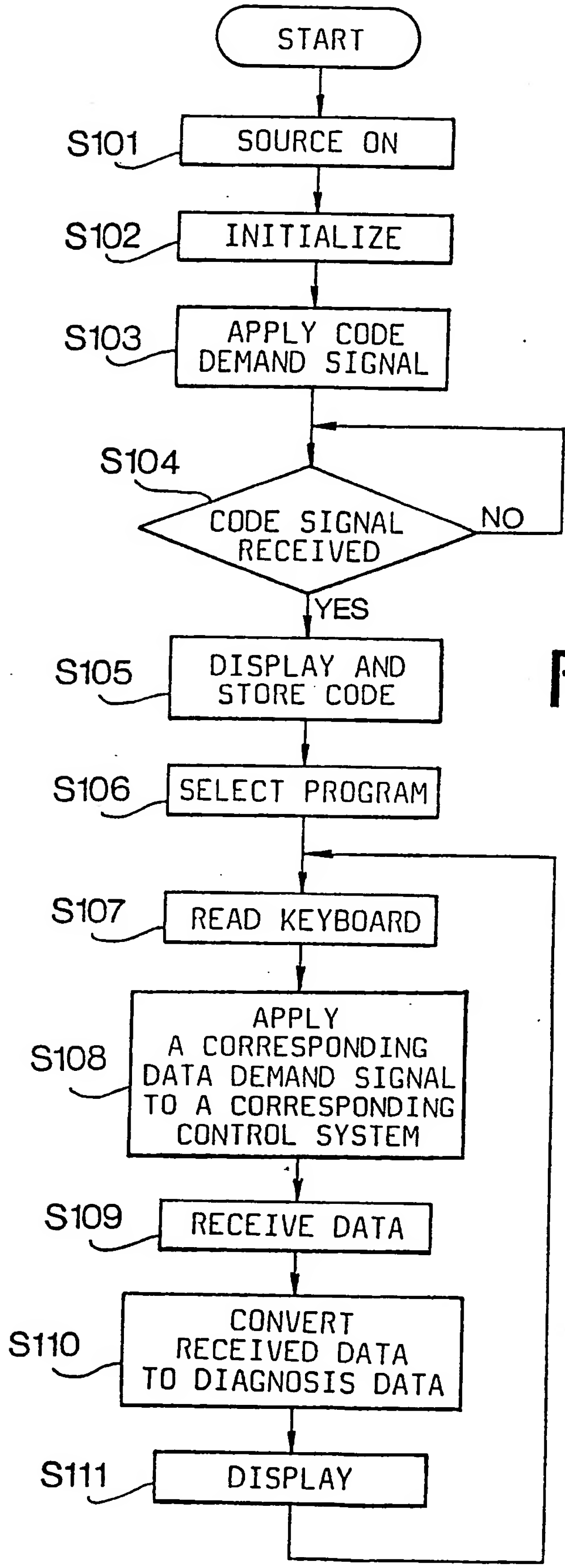


FIG. 4a

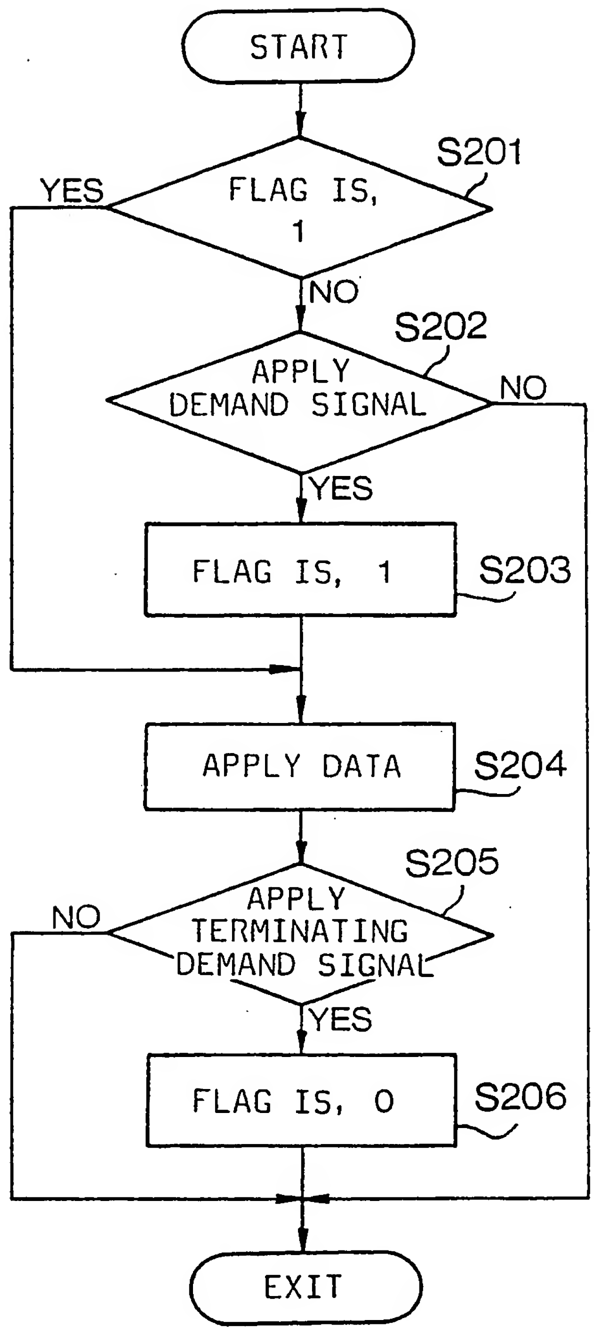
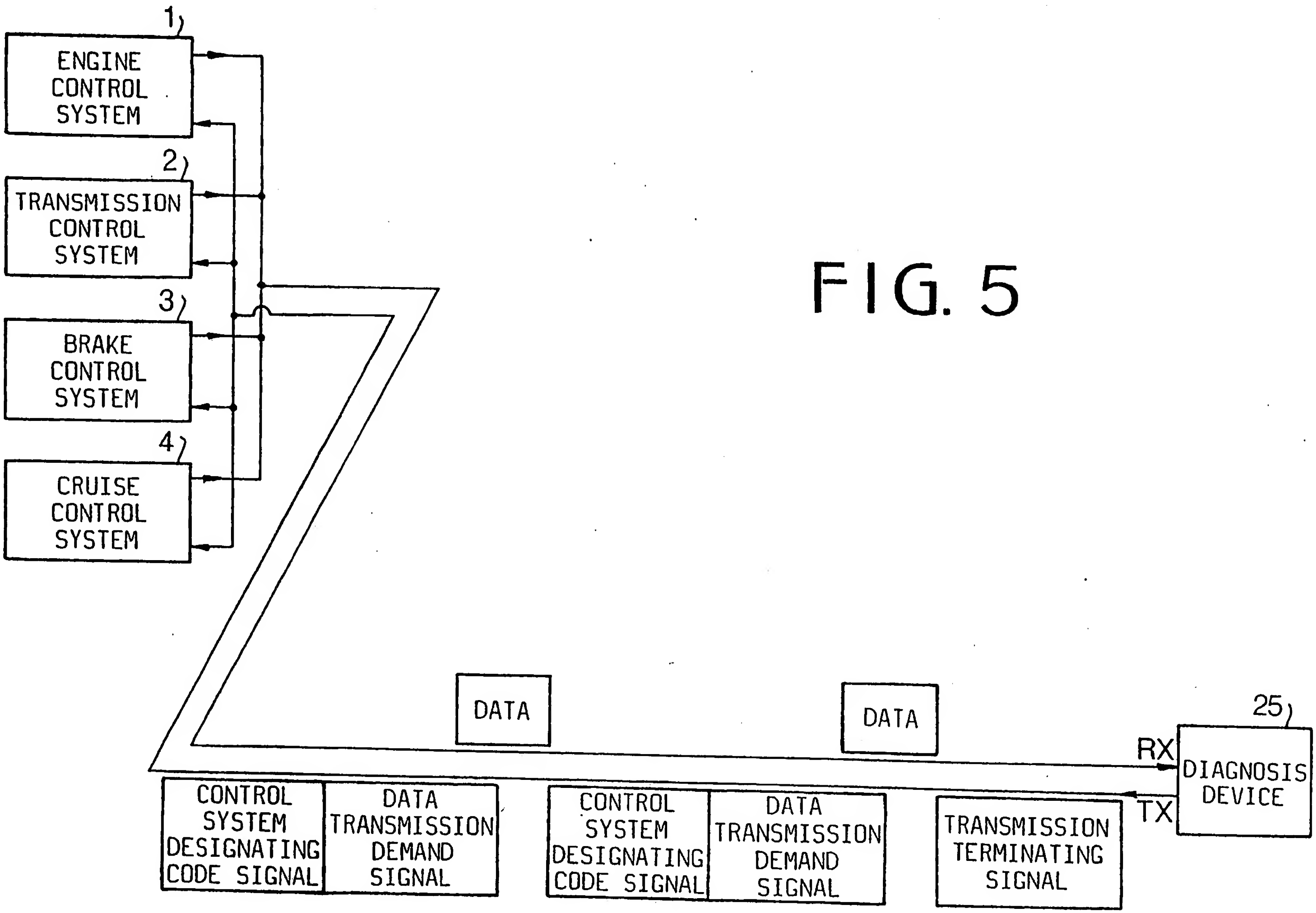

START
FLAG IS, 1
S201
YES
NO
APPLY DEMAND SIGNAL
S202
NO
YES
FLAG IS, 1
S203
APPLY DATA
S204
APPLY TERMINATING DEMAND SIGNAL
S205
NO
YES
FLAG IS, 0
S206
EXIT

FIG. 4b

FIG. 5



1
ENGINE CONTROL SYSTEM
2
TRANSMISSION CONTROL SYSTEM
3
BRAKE CONTROL SYSTEM
4
CRUISE CONTROL SYSTEM
DATA
DATA
25
DIAGNOSIS DEVICE
RX
TX
CONTROL SYSTEM DESIGNATING CODE SIGNAL
DATA TRANSMISSION DEMAND SIGNAL
CONTROL SYSTEM DESIGNATING CODE SIGNAL
DATA TRANSMISSION DEMAND SIGNAL
TRANSMISSION TERMINATING SIGNAL

DIAGNOSTIC SYSTEM FOR A MOTOR VEHICLE

The present invention relates to a diagnostic system for a motor vehicle.

Motor vehicles have recently been equipped with an electronic control system for controlling various components, such as fuel injectors, of the engine thereby improving driveability, exhaust gas emission, fuel consumption and engine power. The electronic control system controls the components based on information represented by output signals from various sensors for detecting engine operating conditions. Accordingly, if malfunction of components and sensors occur, the engine does not operate properly.

Because of the complication of electronic control systems, it is difficult to immediately find out if faults have occurred. Accordingly, a diagnostic device for easily checking the electronic control system should be present in each motor servicing workshop.

Japanese Utility Model Application Laid-Open No. 60-25974 discloses a diagnostic system in which a plurality of connectors are provided between various sensors and control circuits or between various actuators and control circuits. A plurality of decision circuits, holding means and displays are connected to the connectors for detecting abnormality of the system. Since a plurality of connectors,

decision circuits, holding means and displays are provided, the system becomes complicated in structure.

Recently, a diagnostic system has been proposed in which a bi-directional communication system is provided between the electronic control system and the diagnostic device, thereby diagnosing data based on output signals from various sensors and control data for various actuators in the control system through a single diagnostic device.

However, in a motor vehicle, a plurality of electronic control systems, for example, for the engine, transmission, brake and cruise control may be provided. In order to diagnose faults of these control systems, connectors for respective control systems must be connected to a connector of the diagnostic device, which is troublesome work. When a plurality of control systems are faulty at the same time, it is difficult to diagnose those troubles and it takes time to find the faults.

An object of the present invention is to provide a diagnostic system in which diagnostic operations for a plurality of electronic control systems can be accurately and quickly performed.

According to the present invention, there is provided a system for diagnosing a plurality of electronic control systems mounted in a motor vehicle, in which a diagnostic device is connected to each of the control systems and wherein each control system

comprises sensing means for detecting operating conditions of a different part of the vehicle; control means for storing input data from said sensing means and for providing output data for controlling the part of the vehicle; signal receiving means for receiving a data demand signal from the diagnostic device; interpreting means for interpreting the content of the data demand signal; and signal transmitting means for transmitting an output signal in accordance with the interpretation through the interpreting means for the diagnostic device; the diagnostic device comprising a control unit responsive to the output data from the control means for diagnosing said output data and for providing diagnostic data; display means for displaying said diagnostic data and a keyboard for inputting a diagnostic mode into the control units; and the signal receiving means of all the control systems are connected in parallel and via a single line to the diagnostic device and the signal transmitting lines of all the control systems are connected in parallel and via a single line to the diagnostic device.

In order that the invention may be more readily understood, it will now be described, by way of example only, with reference to the accompanying drawings, in which:-

Figure 1 is a schematic illustration of a diagnostic system according to the present invention;

Figs. 2a to 2c show a block diagram of the system;

Figs. 3a and 3b show a block diagram showing a main part of the system;

Fig. 4a is a flowchart showing an operation of a diagnosis device in the system;

Fig. 4b is a flowchart showing an interrupt routine; and

Fig. 5 is a diagram showing a data communication procedure between the electronic control system and the diagnosis device.

Referring to Fig. 1, an automobile 100 is equipped with a plurality of electronic control systems for controlling various components of the automobile 100 such as an electronic engine control system 1 for controlling air-fuel ratio of the engine and others, an electronic transmission control system 2, an electronic brake control system 3 for controlling an antilock brake system, and an electronic cruise control system 4 for constant speed drive of the automobile. These electronic control systems are connected to an external connector 24. A portable diagnosis device 25 comprising a microcomputer is housed in a case 25a and has a connector 26, to which the connector 24 of the system 2 is connected through an adapter harness 27.

The diagnosis device 25 has a power switch SW4, a liquid crystal display 31, an indicator section 30 consisting of a plurality of indicators of LED and a keyboard 32. A connector

33 is provided for connecting a detachable memory cartridge 34.

Referring to Figs. 2a and 2b, the electronic control system 1, 2, 3 and 4 have central processor units (CPUs) 1a, 2a, 3a and 4a, random access memories (RAMs) 1b, 2b, 3b and 4b, read only memories (ROMs) 1c, 2c, 3c and 4c, non-volatile random access memories (non-volatile RAMs) 1d, 2d, 3d and 4d, input interfaces 1g, 2g, 3g and 4g, and output interfaces 1e, 2e, 3e and 4e, respectively. These CPU, RAMs ROM, input and output interfaces in each control system are connected to each other through a bus line. In the RAMs 1b to 4b, various processed parameters and tables are stored. Programs and data for controlling the engine and fixed data such as the type of the vehicle are stored in the ROMs 1c to 4c. Power is supplied to the CPUs, input and output interfaces, and drivers of control systems from a source BV through a contact of a relay RY1 and constant voltage circuits. A coil of the relay RY1 is connected to the source BV through an ignition switch SW10.

The electronic engine control system receives signals from a coolant temperature sensor 9, an O_2 sensor 10, an intake manifold pressure sensor 11, an air conditioner switch SW1, a vehicle speed sensor 13,. an accelerator pedal switch SW5, a throttle position sensor 15, a neutral switch SW3 and an engine speed sensor 17 through the input interface 1g.

These signals are stored in the RAM 1b after the processing of data in accordance with the program stored in the ROM 1c. The CPU 1a produces respective control signals, which are applied to a driver 1h through the output interface 1e. The driver 1h produces signals for controlling a canister controller 19 of a fuel-vapor emission control system, an EGR (exhaust gas recirculation system) actuator 20, an idling control actuator 21, ignition coils 22 and fuel injectors 23.

The electronic transmission control system 2 receives signals from the engine speed sensor 17, vehicle speed sensor 13, accelerator pedal switch SW5, throttle position sensor 15 and neutral switch SW3 through the input interface 2g. The CPU 2a produces a signal which is supplied to an A/T (automatic transmission) actuator 12 through the output interface 2e and a driver 2h, for controlling the transmission in response to driving conditions.

The electronic brake control system 3 receives signals from a brake switch SW6 and a vehicle wheel speed sensor 14 through the input interface 3g. These signals are processed in accordance with the program stored in the ROM 3c for controlling an antilock brake system. A control signal is applied to an ABS actuator 16 through the output interface 3e and a driver 3h.

An electronic cruise control system 4 is supplied with signals from a constant speed drive setting switch SW7 and vehicle speed sensor 13 through the input interface 4g. A

control signal is supplied to a throttle valve actuator 18 through the output interface 4e and a driver 4h for controlling constant speed drive of the vehicle. When signals from the brake switch SW6, the accelerator pedal switch SW5, a deceleration switch SW8 and a resume switch SW9 are supplied to the input interface 4g, release of the constant speed drive or decelerated constant speed drive are performed.

In these control systems 1, 2, 3 and 4, input interfaces 1g to 4g are connected to each other in parallel and output interfaces 1e to 4e are connected to each other in parallel so that bus lines comprising signal transmitting lines and signal receiving lines are formed.

The diagnosis device 25 has a control unit 28 and a power supply source 29. The control unit 28 comprises a CPU 36, a RAM 37, an input/output (I/O) interface 40, and a timer 38. These elements are connected to each other through a bus line 35. A clock pulse generator 42 is provided in the timer 38 for generating synchronizing pulses.

Inputs of the I/O interface 40 are connected to the output interface 1e to 4e of the control systems 1 to 4 through connectors 24 and 26 and harness 27 so as to receive output signals of sensors and switches. Outputs of the interface 40 are connected to the indicator section 30. The indicator section 30 has a plurality of LEDs D_1 to D_{10} which are operated in accordance with switches SW1, SW3, SW5 to SW9. When one of the switches is turned on, a corresponding LED of

LEDs D_1 to D_{10} is lighted or intermittently lighted, so that the operation of the switch can be confirmed. Inputs of the I/O interface 40 are connected to the keyboard 32 for receiving a mode select signal dependent on the operation of the keyboard, and to the output interfaces 1e to 4e. Outputs of interface 40 are connected to the input interfaces 1g to 4g and the display 31. The power source 29 for supplying the power to the CPU 36 and I/O interface 40 is connected to the source BV through the power switch SW4.

The memory cartridge 34 selected for diagnosing the selected control system 2 is connected to the diagnosis device 25 through the connector 33. A ROM 41 provided in the memory cartridge 34 stores control programs for diagnosing the electronic control system of the vehicle and fixed data.

Referring to Fig. 3, the electronic control systems 1 to 4 have calculating means 51a to 51d for calculating signals from sensors and switches, and drivers 1h to 4h connected to the calculating means 51a to 51d for supplying actuating signals to respective actuators. Each of signal receiving means 54a to 54d is provided for receiving data demand signals from the diagnosis device 25. Interpreting means 53a to 53d are provided for interpreting the contents of data demand signals and producing pickup signals which are applied to data pickup means 52a to 52d, respectively. In accordance with pickup signals, data pickup means 52a to 52d pickup data from data calculated in the means 51a to 51d or data stored in ROMs

1c to 4c, and produce data signals, respectively. The data signals are supplied to the diagnosis device 25 through signal transmitting means 55a to 55d which are connected in parallel. Signal receiving means 54a to 54d are connected to each other in parallel. These signal receiving means and transmitting means are connected to the connector 24 through bus lines.

The control unit 28 of the diagnosis device 25 comprises a keyboard interpreting means 58 provided for interpreting designated mode input by the keyboard 32. A data communication means 56 retrieves a designated range of the fixed control program corresponding to the designated mode in accordance with the mode signal from the keyboard interpreting means 58. In accordance with a diagnosis program stored in the designated range, the data communication means 56 produces a data demand signal TX which is applied to the control systems 1 to 4 and receives a data signal RX fed from the control systems. A data calculating means 57 calculates the data received at the data communication means 56 for converting the received binary digit into a decimal digit. A display driving means 59 produces a signal in accordance with the output of the data calculating means 57 for driving the display 31.

The operation of the diagnosis system is described hereinafter with reference to the flowchart of Figs. 4a and 4b. Referring to Fig. 4a, the diagnosis device 25 is connected to the electronic control system 2 through the

connectors 24, 26 and harness 27. The engine is started, and the following diagnosis program is performed under the running of the engine.

The power switch SW4 is turned on at a step S101. At a step S102, initialization of the control unit 28 is performed. At a step S103, a data demand signal TX from the data communication means 56 is applied to the engine control system 1. The data demand signals are previously stored in the ROM 1c.

As shown in Fig. 5, the data demand signal TX comprises a control system designating code signal and a data transmission demand signal. First, the data demand signal TX provides a control system designating code signal for designating the control system, and second, provides a demand signal for demanding an identification code of the control system to the control system. The data demand signal is supplied from the diagnosis device 25 to the control systems 1 to 4 in the order of a control system designating code signal and a data transmission demand signal. That is, first an engine control system designating code signal is supplied and next the data transmission demand signal.

When the control system designating code signal is applied to control systems 1 to 4, actual operation in each system is interrupted and the program proceeds to a step S201 of an interrupt routine shown in Fig. 4b.

At step S201, it is determined whether a signal transmitting flag corresponding to the data transmission demand signal is "1" in each of the interpreting means 53a to 53d of the systems 1 to 4 or not. If the control system designating code signal is fed for the first time, the signal transmitting flag is "0". Thus, the program goes to a step S202 where each of the interpreting means 53a to 53d determines whether the control system designating code signal is applied to respective signal receiving means 54a to 54d or not. In this program, since the code of the engine control system 1 is designated, the program for the engine control system 1 proceeds to a step S203 and programs for the other control systems 2 to 4 proceed to an exit to terminate the interrupt routine.

At that time, since the signal transmitting flag in each of the other control systems 2 to 4 is "0", lines of the signal transmitting means 55b to 55d to the device 25 are opened.

At step S203, the signal transmitting flag of the engine control system 1 is set to "1", and a signal transmitting start signal is fed from the interpreting means 53a to the signal transmitting means 55a. Thus, the signal transmitting means is connected to the diagnosis device 25. The program goes to a step S204 where the interpreting means 53a supplies a signal to the data pickup means 52a to read out an identification code data from the data stored in the ROM 1c.

The derived identification code data signal is fed from the signal transmitting means 55a to the diagnosis device 25.

At a step S205, it is determined whether the interpreting means 53a receives a signal demanding to terminate the signal transmission from the diagnosis device 25. When the termination of the signal transmission is determined, the program goes to a step S206 where the signal transmitting flag is set to "0" and a terminating signal is applied from the interpreting means 53a to the signal transmitting means 55a to open the transmission line to the diagnosis device 25. When the termination demand signal is not received, the interrupt routine terminates.

When the interrupt routine terminates, the main program is resumed. At a step S104, it is determined whether the identification code signal is applied to the control unit 28 or not. If the identification code signal is applied, the program proceeds to a step S105. If not, the program of step S104 is repeated. At the step S105, a received code is stored in a predetermined address of the RAM 37. At a step S106, in accordance with the received code, a program for the type of the control system is selected from the ROM 41 in the cartridge 34. Thus, a diagnosis routine is performed in accordance with the program.

A diagnostician operates the keyboard 32 to perform the diagnosis of the engine control system 1. For example, in order to measure the coolant temperature, a mode code for the

coolant temperature (for example F $\rightarrow$ 0 $\rightarrow$ 7 $\rightarrow$ ENT) is input by operating the keyboard 32 at a step S107. The input mode is read by the CPU 36 and temporarily stored in the RAM 37. Thereafter, the mode is read and interpreted in the keyboard interpreting means 58. A program according to a mode 07 representing a coolant temperature sensor output data program is read out. At a step 108, a corresponding data demand signal TX (for example, coolant temperature data in the engine control system 1) is applied to a corresponding control system from the data communication means 56 in such an order as Fig. 5.

In control systems 1 to 4, the programs of interrupt routines are started. As described above, the signal transmitting flags in control systems 2 to 4 are "0", and the programs for the systems 2 to 4 go from step S201 to step S202 and to the exit.

On the other hand, the engine control system 1 is in signal transmitting state for the identification code demand signal and the signal transmitting flag remains "1". Thus, the program goes from step S201 to step S204 where a data demand signal for coolant temperature is interpreted at the interpreting means 53a. The data demand signal for coolant temperature is applied to the data pickup means 52a. The data pickup means 52a interrupts the identification code pickup operation and operates to pick up coolant temperature data which is supplied to the diagnosis device 25 through the

signal transmitting means 55a. At a step S109, a data signal RX representing coolant temperature is applied to the data communication means 56 from the engine control system 1. At a step S110, the received binary digit is converted into decimal digit representing the coolant temperature in the data calculating means 57.

The driving means 59 produces a calculated data which is applied to the display 31. At a step S111, a measured value of the coolant temperature, for example, +14 deg C representing the temperature, an abbreviation mark TW of coolant temperature, and the input mode indiction F07 are displayed on the display 31 as shown in Fig. 1. Thus, the diagnostician can diagnose the items about the coolant temperature.

In order to perform other diagnosis items, for example, to diagnose vehicle wheel speed data based on a signal from the vehicle wheel speed sensor 14 of the brake control system 3, the diagnostician operates the keyboard 32 to input a mode code for the vehicle wheel speed (for example F →B →1 →ENT) (step S107). The input mode is read and interpreted at the keyboard interpreting means 58. At step S108, the corresponding data demand signal TX for vehicle wheel speed is applied to the control systems 1 to 4 in the order of a brake control system designating code signal and a data transmission demand signal.

At that time, the engine control system 1 is under the condition for transmitting the coolant temperature data. Accordingly, when the interpreting means 53a of the control system 1 receives the data demand signal for the brake control system 3, the interpreting means 53a regards the data demand signal as a signal transmission terminating demand signal at a step S205. Thus, the program proceeds to a step S206 where the signal transmitting flag is set to "0". The interpreting means 53a produces a signal transmission terminating signal which is applied to the signal transmitting means 55a and the data pickup means 52a. The signal transmitting operation of the means 55a is terminated so that the line from the control system 1 to the diagnosis device 25 is opened. The data pickup means 52a terminates the pickup operation for the coolant temperature data.

Simultaneously, control systems 2 to 4 start the interrupt routine. The signal transmitting flags of the control systems 2 to 4 are "0" at step S201 and hence the programs go to step S202. Since the brake control system code is designated, the program of the brake control system 3 goes to step S203. The programs of the control systems 2 and 4 go to the exit to terminate the interrupt programs.

At step S203, the signal transmitting flag of the brake control system 3 is set to "1", and a signal transmitting start signal is fed from the interpreting means 53c to the signal transmitting means 55c. Thus, the signal transmitting

means is connected to the diagnosis device 25. The program goes to a step S204 where the interpreting means 53c supplies a signal to the data pickup means 52c to read out the vehicle wheel speed data from the data stored in the RAM 3b. A derived wheel speed code data signal is fed from the signal transmitting means 55c to the diagnosis device 25.

At step S109, data signal RX representing the vehicle wheel speed is applied to the data communication means 56 from the control system 3. At step S110, the received binary digit is converted into the decimal digit representing the vehicle wheel speed in the data calculating means 57. At step S111, a calculated value of the vehicle wheel speed is displayed on the display 31.

Finally, when the switch SW4 is turned off, the signal transmission terminating demand signal is applied to control systems 1 .to 4. The program of the brake controle system 3 goes from step S205 to step S206 where the signal transmitting flag is set to "0". A terminating signal is applied from the interpreting means 53c to the data pickup means 52c and the signal transmitting means 55c to terminate the signal transmitting operation of the brake control system 3.

In the present invention, diagnoses of a plurality of the electronic control systems 1 to 4 can be performed by connecting them to the diagnosis device 25 through the single external connector 24. For example, the vehicle speed data from the vehicle speed sensor 13, which is necessary for

diagnosing the engine control system 1, transmission control system 2, and cruise control system 4, can be diagnosed by inputting a corresponding diagnosis mode through the keyboard 32. More particularly, if the vehicle speed data in all of the control systems 1, 2 and 4 are abnormal, it is diagnosed that the vehicle speed sensor 13 is in trouble. If the vehicle speed data in one of the control systems 1, 2 and 4 is abnormal, troubles such as faulty contact of the connector or a short circuit in the control system and the sensor 13, breaking of wires, or mulfunction of that control system are assumed.

In accordance with the present invention, a plurality of electronic control systems provided in the automobile are connected to a diagnosis device through a single external connector. Diagnoses of a plurality of control systems are performed with a simple operation without changing the connector to the other one. Thus, workability is improved and troubles in the control systems can be easily found out. Since the single external connector is used, the number of parts and manufacturing cost are reduced.

While the presently preferred embodiment of the present invention has been shown and described, it is to be understood that this disclosure is for the purpose of illustration and that various changes and modifications may be made without departing from the scope of the invention as set forth in the appended claims.

Claims:

1. A system for diagnosing a plurality of electronic control systems mounted in a motor vehicle, in which a diagnostic device is connected to each of the control systems and wherein each control system comprises sensing means for detecting operating conditions of a different part of the vehicle; control means for storing input data from said sensing means and for providing output data for controlling the part of the vehicle; signal receiving means for receiving a data demand signal from the diagnostic device; interpreting means for interpreting the content of the data demand signal; and signal transmitting means for transmitting an output signal in accordance with the interpretation through the interpreting means for the diagnostic device; the diagnostic device comprising a control unit responsive to the output data from the control means for diagnosing said output data and for providing diagnostic data; display means for displaying said diagnostic data and a keyboard for inputting a diagnostic mode into the control units; and the signal receiving means of all the control systems are connected in parallel and via a single line to the diagnostic device and the signal transmitting lines of all the control systems are connected in parallel and via a single line to the diagnostic device.

2. A system as claimed in claim 1, in which the diagnostic device includes a computer having a central processing unit and a memory having a plurality of diagnostic programs for diagnosing the control systems.

3. A system for diagnosing a plurality of electronic control systems mounted in a motor vehicle substantially as hereinbefore described with reference to the accompanying drawings.

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